2.7 Achieving Confidence In The Life Prediction Methodology

As discussed in Section 2.4, airframe life predictions are based on a crack growth damage package that interrelates the following six elements: a) initial flaw distributions, b) aircraft usage, c) basic crack growth material properties, d) crack/structural properties, e) damage model, and f) fracture or life limiting criteria.

Since life predictions for service hardware are based on the crack growth damage integration package, the confidence in a life prediction value must be based on a measure of the ability for a given package to predict measured phenomena. To support evaluation of the damage integration package, laboratory tests are conducted which simulate the basic features of cracked hardware. Predictions are then compared to measured crack growth behavior. The confidence normally associated with life predictions using a damage integration package is derived from the ability of the package to predict the laboratory generated crack growth behavior.

Verification of the package is normally conducted in steps progressing from predictions of laboratory-generated fatigue crack growth data (for which all test conditions are reasonably well characterized and documented) to predictions of service-experienced cracking behavior. Verifying the package in steps allows for immediate deletion of inaccurate or erroneous assumptions made in developing or improving a given element of the package. Since the package will be used to make life predictions where unknowns (e.g. spectra, structural load interactions) prevail, it is essential that confidence be established for each level of prediction capability that has been achieved.

A change of any fundamental element within the package (e.g., retardation model) generally requires a resubstantiation of this confidence for the revised package. An extension of capability, i.e., more complex geometry, would require only a substantiation for that level of complexity. This approach must be taken because of the substantiated influence of each of the variables associated with the individual elements.

Only when cracking is evident from service inspections can there be the necessary information to verify that the damage integration package is performing satisfactorily. The difficulty of assessing the confidence level associated with the life prediction derived from the damage integration package results from extrapolating the use of the package from a simple data base to the more complex service hardware case.

Figures 2.7.1 through 2.7.3 are provided as examples to show how elements within a package are verified. All figures show the correlation between predicted and measured life. Figure 2.7.1 provides an evaluation of a new retardation model in which the database was a measure of the cyclic delay subsequent to an overload. Figure 2.7.2 compares the predictions developed with the AFWAL-Willenborg-retardation model (damage integration package to laboratory test data) which show the influences of spectra and crack geometry changes. Figure 2.7.3 shows the evaluation of a AFWAL modified damage integration package which accounts specifically for C-5A spectra changes on life observed when the crack geometry is a radial corner crack growing from an open or plugged hole.

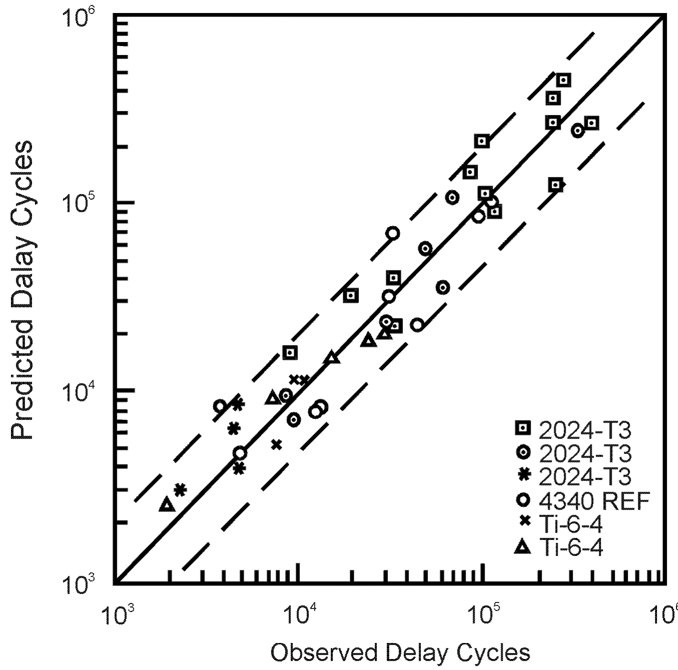

Figure 2.7.1. Single Overload Correlation with Modified Wheeler Retardation Model

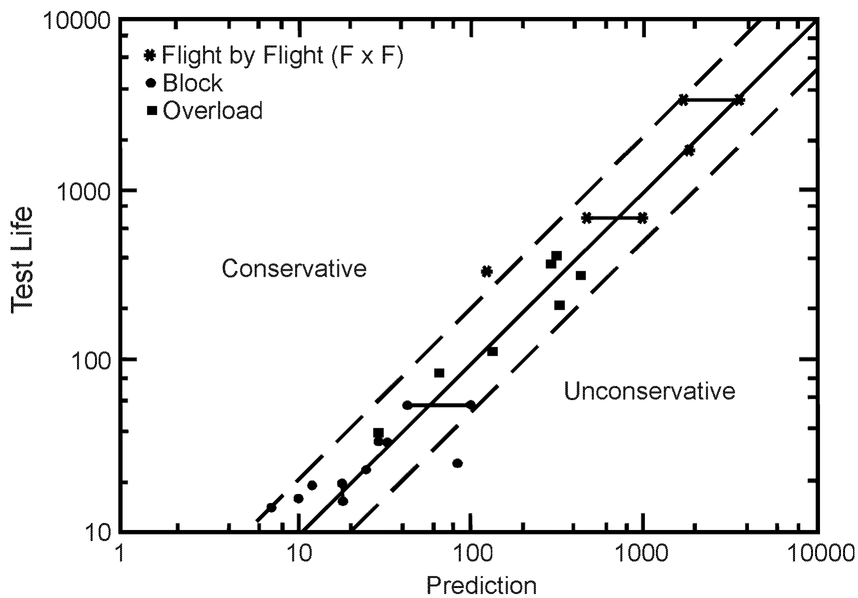

Figure 2.7.2. Spectrum Correlation Using the AFWAL Willenborg-Retardation-Model (Damage Integration Package)

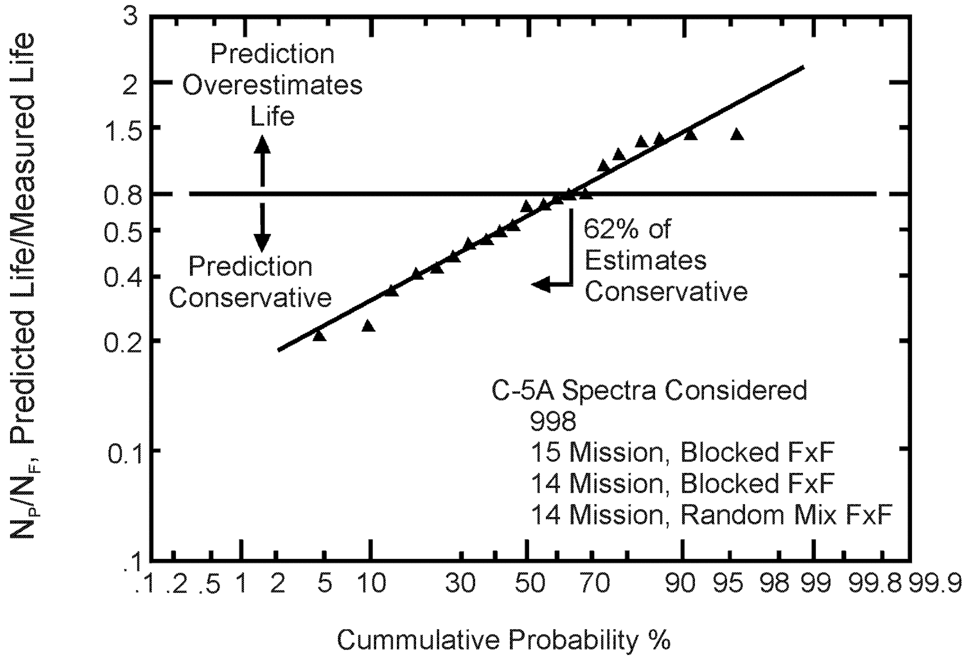

Figure 2.7.3. Prediction Capability of Damage Integration Package (Based on 21 Laboratory Tests Conducted at AFWAL/FIB)